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ABSTRACT

Science programs provided for primary school have not always been successful. A major reason suggested is that some programs place demands on teachers which many teachers find difficult to meet and which give rise to concerns which restrict their development as teachers of science. Based on the work of the the Learning in Science Project (Primary)--LISP(P)--in New Zealand, various concerns of teachers are considered. They include: (1) their limited background in science; (2) their belief that hands-on inquiry is the only acceptable form of science activity in the primary classroom; (3) their ability to manage a class effectively and maintain appropriate student behavior; (4) their ability to organize necessary resource materials; (5) their concern about evaluation; (6) their choice of topics for the science program; and (7) their influence on children's ideas. An approach is suggested designed to promote teachers' professional growth in the teaching of science so that they can move from these concerns of self to concerns about learners. Science programs are proposed which allow teachers both to cope effectively and to focus on children's thinking about natural phenomena. The current research of the Learning in LISP(P) focuses on exploring the practicality and the potential of these proposals. (Author/JN)

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LEARNING IN SCIENCE PROJECT (PRIMARY)

TOWARD PROFESSIONAL DEVELOPMENT IN SCIENCE EDUCATION FOR THE PRIMARY SCHOOL TEACHER

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Working Paper No. 119

TOWARD PROFESSIONAL DEVELOPMENT IN SCIENCE EDUCATION

FOR THE PRIMARY SCHOOL TEACHER

David Symington and Roger Osborne

ABSTRACT

Science programmes provided for primary school teachers have not always been successful. The authors argue that a major reason for this is that many programmes place demands on teachers which many teachers find difficult to meet and which give rise to concerns which restrict their development as teachers of science. Based on the work of the Learning in Science Project (Primary) in New Zealand, various concerns of teachers are considered. These include: their limited background in science, their belief that the only acceptable form of science activity in the primary classroom is that which involves pupils in "hands-on" enquiry, their ability to manage an activity based programme effectively, their ability to organise necessary resource materials, their choice of topic for the science programme, and their influence on children's ideas.

The authors suggest that ways need to be found to promote teachers' professional growth in the teaching of science so that teachers move from concerns of self to concerns about learners. Science programmes are proposed which allow teachers both to cope effectively and to focus on children's thinking about natural phenomena. The current research of the Learning in Science Project is exploring the practicality and the potential of the proposals.

Toward professional development in science education for the primary school teacher

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November 1983

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INTRODUCTION

Despite the fact that considerable effort has gone into constructing new programmes in primary science in recent years, many teachers in various countries have either completely rejected, or given only token recognition to, those presented to them. A number of factors has been suggested in explanation, for example, shortage of equipment (Biddulph, 1982), teachers' lack of background in science (Plimmer, 1981) and too much preparation time required (Appleton, 1977).

It is our view that the science programmes may be placing demands on primary teachers which many find difficult to meet and which give rise to teacher concerns which restrict their professional development. In this paper we provide an analysis of likely teacher concerns and argue that these must be taken into account when designing a science programme. Such a programme should enhance teachers' professional growth at the same time as it promotes children's learning.

Teacher concerns

A useful framework within which to examine teacher concerns is that provided by Fuller (1969). She holds the view that the nature of teacher concerns changes as teachers develop professionally. She contends that early in their careers they are concerned with self interests while later their concerns shift to focus more on their pupils. For example, early in their careers some teachers are concerned about their,

> 'abilities to understand subject matter, to know the answers, to say "I don't know", to have the freedom to fail on occasion, to anticipate problems, to mobilize resources, and to make changes when failures reoccur'.
> (Fuller, 1969, p.220)

By contrast, their later concerns include,

> "concern about ability to understand pupils' capabilities, to specify objectives for them, to assess their gain, to partial out one's own contribution to pupils' difficulties and to evaluate oneself in terms of pupil gain"
> (Fuller, 1969, p.221)

Considerable concern with self is understandable in young teachers but when displayed by experienced teachers indicates an unfortunate breakdown in professional development. Our observations suggest that with some experienced teachers this breakdown may be largely confined to science Teachers can express concerns typical of those of the later phase in other curriculum areas but in science they can be concerned about such things as their own knowledge of science and their ability to manage equipment. Our view is that this results from a range of factors hitherto overlooked or underrated in science curriculum design.

What are these factors which appear to hold teachers in the phase of early concerns in their science teaching? And what steps can be taken to support them in a shift to the phase of later concerns; particularly to concerns about pupils' learning in science? These are the questions which we now address. We shall examine a number of factors which seem to us to be important, and we shall propose various suggestions designed to promote teachers' professional growth. The ideas largely result from our involvement in the Learning in Science Project (Primary).[1]

Concerns about scientific knowledge

Many primary teachers do not have strong backgrounds in science. In the view of Swartz (1983), those who elect to become primary teachers come from the group who lack a background in science. Despite two decades of being assured that their lack of science background is no real handicap as far as teaching science is concerned, many remain skeptical.

> "The greatest problem for me is a lack of background knowledge of biology. Because of that I tend to shy away from nature study and I find all sorts of excuses for not doing nature study. I'll do something else instead." (Interview with teacher)[2]

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1. A New Zealand government funded research project investigating the teaching and learning of science in the primary school.
2. As part of the exploratory phases of the Learning in Science Project (LISP) teachers were interviewed. Quotations used in this paper are from that source.

Even where courses have emphasized the development of skills, such as observing, measuring and experimenting, teachers have been unwilling to dismiss the content as insignificant.

> "But this one we're going on to now about mixtures, I'm dreading - solutions and solvents and all that because I know nothing about it and it's going to involve a lot of, sort of, experimenting and, sort of, having to guide the children so that they're going to make hypotheses and then, sort of, guide them again so that they're going to come up with the right, sort of, answers. Well if you don't know yourself or you're not sure yourself - what are the right, sort of, answers to come up with - how are you supposed to sort of guide them to - and we're not supposed to have much say in it anyway - are we?" (Interview with teacher)

Undoubtedly primary teachers need support with respect to content. But what is the nature of the required support? Some curriculum developers have included scientific background in "teacher notes". This approach seems unlikely to reduce teachers' concern about their lack of background. Rather it may strengthen it. The presentation of a "correct" scientific explanation is frequently interpreted as meaning that this scientific viewpoint is important and is what should be imparted to children in some form at least.

In our view the emphasis needs to be shifted from concern with the scientist's view to concern with the child's present view. If the teaching process can be developed around the ideas and information the children bring with them to the classroom then the teacher's reservations about science might be reversed. For this sort of approach teachers need certain information. This includes:

(i) the views that children are likely to bring with them to the science lesson,

(ii) an indication of which of these ideas are more useful in terms of making sense of the world and which are not and why, and

(iii) suggestions as to how, in what way, and for what reason these children's ideas can be challenged, modified, or further developed.

Biddulph, Freyberg and Osborne (1983) provide an example of such information in a handbook for primary teachers on the topic of "Floating and Sinking". The information on children's ideas included in the

booklet had been obtained previously (Biddulph, 1983). The booklet discusses the usefulness of these ideas in making sense of the world. It also includes activities some of which are designed to confront the children with experimental evidence contrary to their present ideas. For example, an investigation is suggested to test the notion, found to be held by many children, that the depth of water under a floating object influences the level of flotation.

Teachers equipped with the likely views of children, the scientist's views based on experimental evidence, and some suggested investigations are well prepared in terms of background information. We hope that this approach will contribute toward freeing teachers from concerns about their own background in science and will encourage them to be more concerned about pupil learning and about the prior experiences and understandings that pupils bring to the lessons. We will return to this point again later.

Concerns about scientific investigations

Many of the recent programmes for science in the primary school have emphasized direct experimentation by pupils; sometimes called 'hands-on' activity. Although the programmes have varied in their orientation - for example in Science : A Process Approach the emphasis was on the scientific skills being used, while in Science 5/13 the emphasis was on pupils' answers to their questions - the message for many teachers was that pupils should be constantly interacting with objects and equipment. There have been some problems with this largely experimental approach. Sometimes teachers and more frequently pupils lost sight of the purpose of such activities. The mismatch between children's questions and the objects and equipment available for use in answering the questions could also be a problem.

In addition, the emphasis on experimental work has not always matched the interests and abilities of primary teachers themselves. Our experience has been that many primary teachers either had unfortunate experiences with experimental work, or simply preferred more 'bookish' science projects, during their school years. As a consequence they left the

experimental work that they were required to undertake to more competent, science orientated students. Also the need for experimentation was not always clear to them as often the answers were already known and frequently not supported by the data from their own investigation. If primary teachers who have had such experiences interpret primary science programmes as requiring constant pupil experimentation this is likely to reinforce concerns of self.

In our view primary science education needs to affirm that pupils' ideas should be investigated in the most appropriate way. Frequently this will involve 'hands-on' investigation, but not invariably. Asking someone else's Mum or Dad because she or he is an expert, or finding out from books, should not necessarily be considered as second-rate scientific activities. After all scientists solve their problems by asking the advice of experts - often colleagues, reading about the investigations undertaken by others and, where necessary, making observations and conducting experiments themselves. Much worthwhile scientific activity for both scientists and pupils will involve reading, asking others and discussing.

The effect on teachers of broadening their perception of what are acceptable means of enquiry in science can be very positive. For example, one primary teacher who believed that 'hands-on' enquiry was the only acceptable learning strategy in primary science felt relieved to find that the use of reference material was a strategy used by scientists and could be equally acceptable in primary science education. Her subsequent enthusiasm for science teaching suggested that this idea lifted her from a concern for self to a concern for pupils' views and learning.

Concerns about pupil management

Not only do recent programmes for science in the primary school advocate that pupils interact with materials but most suggest that this activity should be carried out in small groups. All this has to happen in a classroom not architecturally designed for such activities and where there is frequently a pupil:teacher ratio greater than 30:1.

Teachers need to feel that they are guiding pupil learning and it is easy to understand the feelings of a teacher who wants pupils to focus on a particular issue or who wants to conduct a class discussion, while the children, for their part, simply want to continue exploring with the materials. It is indeed a talented teacher who can hold the attention of a class of pupils who have snails travelling across their desks. Or again, the provision of materials provides very obvious ways for children to digress from what the teacher intends them to do, so that they fail to understand the planned purpose of the lesson, and their part in it. Whereas in another subject lesson they may quietly daydream, the provision of materials in science offers a multitude of opportunities to engage in activities which contribute to teacher anxiety.

> "I think a lot depends on the individual teacher really, and the environment, the type of child. I mean in a small class like we've got with reasonably well behaved children, as compared with others very well behaved, the children can question what you say, have a discussion about it. Whereas if you have got a large class you have got to be more of a strict disciplinarian." (Interview with teacher)

Clearly, there are teachers who can cope, and who are able to concern themselves with pupil learning. But for many, the provision of rarely experienced materials poses a threat to their ability to control the learning experience let alone the learning itself. This concern is more typical of the beginning teacher in most subject areas but appears to be common with respect to science.

We would argue that unintended behaviours are caused in part by curriculum writers' and teachers' lack of knowledge of pupils' ideas and thinking. Where activities relate to children's ideas; where the purpose of the activity is clear in terms of the children's present ideas; where the activity is seen by the children as the obvious way to answer what is, or has become, their genuine question, then not only is learning on-track but pupil management becomes less of a problem. Such a pupil-oriented lesson is possible even with first year teachers. An example can be found in Biddulph and Roger (1983).

It should be made clear that teacher concern for pupils' learning involves active teaching. Such teaching would include continual cajolling and encouraging of pupils, reflecting and challenging their ideas, and suggesting how they can follow up their tentative ideas. Teacher education and/or teachers' guide-material must do more than suggest activities for pupils to undertake; it must also give teachers guidance in the active roles they need to perform to provide the best possible learning environment for pupils (Osborne, 1983).

A final issue with respect to pupil management which it seems appropriate to raise is whether good science learning always necessitates small groups of pupils interacting with materials. Is there a place, for example, for the teacher demonstrating an event to a whole class? We believe there is; in appropriate circumstances a teacher demonstration can provide the basis for worthwhile pupil learning. Is there a place for teacher-led whole class discussions? Again we believe there is; such discussions may help focus children's thinking. Dealing with a class as a total group is a form of pupil management with which most primary teachers feel comfortable and would therefore allow them to focus their concerns on pupil learning.

Concerns about resource management

Science teaching in the primary school classroom requires resource management skills of no small order. Space must be found for the storage of materials. Suitable places may have to be found to site animals or plants, and such living things need to be maintained over a period of time. Water may be needed although there may be no running water in the classroom. Items of equipment need to be assembled. Equipment which has strayed, or been broken, needs to be replaced. Appropriate reference books need to be identified and made available. The list could go on. There are primary teachers who excel at such resource management but, not surprisingly, there are others who are concerned about their ability to manage these aspects of science teaching.

The wide spectrum of experience, abilities and concerns about resource management found amongst primary teachers is rarely acknowledged in science programmes. In our view teachers' guide material should cater for this wide range of experiences and abilities. For teachers with appropriate management skills, good material resources and access to additional classroom help - for example, parents, student teachers, and teacher aides - relatively complex programs are manageable, provided they have sufficient flexibility to be adaptable to individual pupils' learning needs. For other teachers, however, the guide materials should take fully into account the managerial issues that can arise. A much more limited range of prestructured activities designed to make use of limited resources seem more appropriate here. Such activities, it must be emphasised, should also be based on, and oriented towards, pupils' ideas and questions. It is hoped that, with sufficient support and guidance, teachers who are less confident about their ability to manage science learning will be able to focus more on pupils and less on self.

Concerns about coping with a topic

The grounds on which teachers choose certain topics to teach vary from teacher to teacher. Some choose topics which they consider will benefit the children. Others, however, being concerned with their own abilities are likely to choose topics which appear to pose the least possible threat to themselves. They may, for example, choose a topic because the content is familiar, because the need for pupil management will be minimized, or because few resources are required.

> "Last year I remember just at the last minute I swapped over and I did another topic - I think actually I did weather - I was actually going to do the solar system - cause I thought, well that one I'll have to learn something about, I'll enjoy doing it. But at the last minute I just couldn't find enough material so I changed to weather."
>
> (Interview with teacher)

In our view science programmes need to support teachers to move from the position where the choice of topics reflects a concern for self to one where the choice reflects a concern for the pupils.

A necessary condition for this shift to occur is that the teachers are able to recognise a topic as knowledge of worth for pupils as individuals and/or members of society (Fensham, 1983). Such recognition may not be easy because many primary teachers, whilst not among the most successful in learning science at school, not unreasonably consider that it has been no great impediment to their personal happiness, career successes or societal obligations. They need to see that what is proposed will be of real value to the pupils in their lifetimes, if not immediately. Teachers may deem something as knowledge of worth for a range of reasons. These include:

(i) personal conviction that the knowledge has been worthwhile to them personally and hence of likely worth to pupils, e.g. ideas on nutrition,

(ii) a belief that pupils would value the knowledge personally, e.g. how to read a TV weather map, and

(iii) a feeling that the knowledge would be judged of worth for children by parents and other community members, e.g. learning about electricity.

To different teachers, for different topics, and for different pupils, the knowledge of worth may be specific facts, understandings of natural phenomena, understandings of the nature and reliability of information, specific processing strategies, or practical skills.

Teachers undoubtedly need guidance about the potential of topics in terms of knowledge of worth to pupils. If teachers' guide material can set out and emphasise such issues as they relate to pupils' learning then this may provide a further means to enable teachers to move from concerns for self to concerns for pupils. It is this latter basis upon which the choice of topics needs to be made.

Concerns about pupils' ideas

In the early phase of teacher concerns, interest in pupils' ideas are often rather superficial and are part of the teacher's preoccupation with his or her teaching rather than with pupil learning. Rather than exploring children's ideas for their own sake, teachers in this phase often select, from the ideas they elicit from pupils, those that they can use to try to lead the pupils toward a predetermined objective; an objective which may be entirely inappropriate for those pupils.

> "Let's put it this way : we ..... tend to elicit the type of response that we feel we ought to get so even in perhaps some of our better lessons ... we think we know the line of questioning that we want to follow and we do this fairly religiously to reach a point that we've presupposed that we should reach ... And maybe we tend to inhibit a lot of development that might be equally as valid or even more valid than that which arises from a [sort after] response. We tend to knock [alternatives] on the head because we want to reach our original objective which may not be as good as following the line that comes out of the child's response. We're a pretty structured sort of lot."
>
> (Interview with teacher)

As the above quotation indicates there are teachers who realise that possibilities for learning are being missed because they are not able to capitalise on the children's ideas. In our view teachers can be helped toward the "pupil concern" phase of science teaching by learning about and gaining experience in techniques to find out children's ideas, by knowledge of the ideas that children have with respect to specific topics, and by knowledge of how these ideas may be utilised in teaching.

The activity of science education researchers in many countries, including work done at the Science Education Research Unit at the University of Waikato, is resulting in both an increased body of knowledge about children's ideas and methods to elicit these ideas. A particularly interesting aspect of this research is that researchers in different countries have developed similar methods to probe children's ideas of natural phenomena, and that the ideas held by children in developed countries of the Western world have been found to be remarkably

similar. Thus the incorporation of particularly relevant aspects of children's ideas in a succinct form in teacher's guide material on a topic should increasingly become common as such information is established by research. Curriculum developer/researcher produced surveys, based on typical views known to be held by children on a topic, can be useful too. Teachers are then able to quickly and easily assess the prevalence of certain views amongst their own pupils. (For an example of such a survey see Bell, 1981.) Where research information about children's views on a topic is not available the use of methods such as interview-about-instances (Osborne and Gilbert, 1980), interview- about-events (Osborne, 1980) and prediction - observation - explanation (White, 1982), by a teacher with groups of children or the whole class can yield information about the children's ideas. Eliciting children's questions on a topic is another way that teachers might use to gain insight into their thinking.

The availability of information about children's ideas, and methods to probe them, in our experience, can make teachers more sensitive to the views pupils hold. In so doing teachers can be assisted in the transition from concern for self to concern for pupil learning.

Concerns about outcomes

During the early teaching phase teachers tend to evaluate their success in terms of the readily observable - whether the management was effective, whether control was maintained, whether the teacher was able to sustain his or her position as a source of knowledge, and so on. However, as teachers move toward the later phase they begin to question what it is they are or should be evaluating. This is illustrated by one teacher who reflected,

> "I guess I would like to have investigated whether or not the sort of things that teachers do in classrooms with natural science actually has a great deal of impact in terms of the change of attitude that occurs with children, any learning that actually occurs, whether the children do gain any knowledge even."
>
> (Interview with teacher)

No teacher can control what a child will actually learn but there is nothing more likely to build teacher confidence than to gain evidence that desired changes in pupils' knowledge and behaviour has occurred and can be controlled by the learning environment orchestrated by the teacher. Again, it is helpful in this context not simply to consider, and to assess, how successfully children can demonstrate scientists' thinking, language and skills. Rather both teachers and learners need to be centrally concerned with the elaboration, and/or modification of the childrens' ideas. For many learners this will only occur if the assessment mechanisms adequately reflect this concern.

As a first step in this assessment process, surveys which identify the range of views children hold can be used prior to, and after, teaching to gauge learning. It is also important to monitor the considerable change that can result over the 3-12 months following teaching. Sometimes other formal and incidental learning can reinforce new views. However, at other times a new view may not survive the pupil's subsequent experiences and pupils revert to ideas held prior to teaching. We have just begun to appreciate the complexities of adequate assessment which maximizes feedback for valuable learning; being neither too quick to damn alternative viewpoints nor too eager to praise all views offered. Such problems indeed provide challenges of the right type for teachers who have concerns about pupils' learning rather than about self.

CONCLUSION

In this paper we have attempted to show that the developmental conceptualisation of teacher concerns suggested by Fuller (1969) provides a useful framework to examine teacher response to primary science. A number of issues has been identified which we consider are of concern to many teachers : their limited backgrounds in science, their belief that the only acceptable form of science activity in the primary classroom is that which involves pupils in "hands-on" enquiry, their ability to manage the class effectively and maintain appropriate pupil behaviour, their ability to organise necessary resource materials, and their choice of topics for the science programme.

The approach which we are advocating as a means of facilitating the movement of teachers from concerns of self to concerns about learners is to involve the teacher in situations which allow them to cope effectively, and at the same time gain greater insights into childrens' thinking about natural phenomena. What is required to create a non-threatening context may differ from teacher to teacher, but many teachers will require teacher-guide material specifically written with some of the above issues in mind. If this can be done effectively then issues which were previously of concern will hopefully become less significant and the teacher will move on to issues of pupil learning. In this way, supported ideally by in-service education, primary teachers should develop professionally in terms of science teaching.

The task which we propose for those concerned with programme and teacher development is that of exploring ways in which teachers can be provided with appropriate methods of entering into the world of children's thinking about natural phenomena and of determining what support various groups of teachers need to operate effectively in that world. It is this task that the Learning in Science Project (Primary) is currently tackling.

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